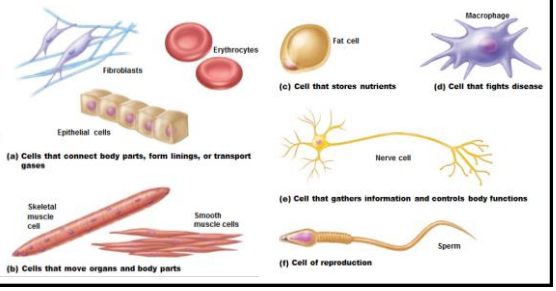
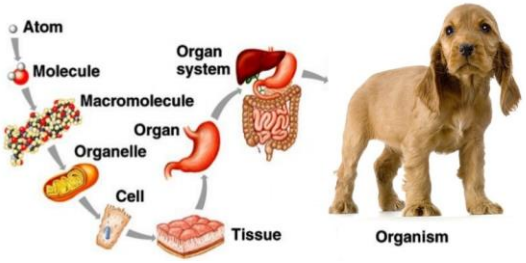
More Cell Notes

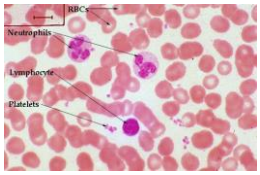
Pre-AP Biology

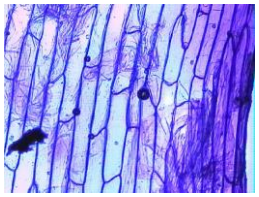


Cell Size

Why are cells so small?





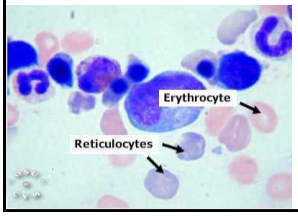


- Most cells are between 2µm and 200µm
- A micrometer is 1 millionth of a meter!
- Too small to be seen with naked eye

Why can't organisms be one big giant cell?

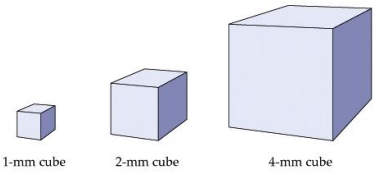
Limits

- Diffusion limits cell size
  - Movement from higher concentration to lower concentration
  - Larger the distance, slower the diffusion rate
  - A cell 20 cm would require months for nutrients to get to the center



- **DNA limits cell size**
  - larger cells need more DNA. Needs more of everything

Surface area to volume ratio limits size



Surface area	6 sides × 1^2 = 6 mm^2	6 sides × 2^2 = 24 mm^2	6 sides × 4^2 = 96 mm^2
Volume	1^3 = 1 mm^3	2^3 = 8 mm^3	4^3 = 64 mm^3
Surface area-to-volume ratio	6/1	3/1	1.5/1

- Volume increase more rapidly than surface area.
- Cell size doubles, 8x as much volume, but only 4x as much surface area
- So, if too big is a problem, what's the solution? Cells divide before they become too big
  - Process of cell division is called mitosis

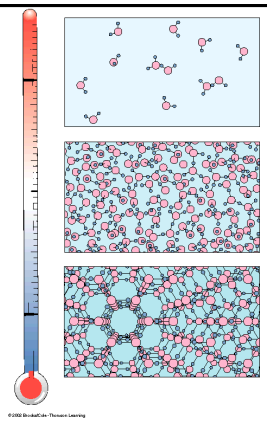
Why do cells divide?

- Replacement – in multicellular organisms to replace worn out cells (ie: stomach lining)
- Repair – replace damaged cells (ie: heal a skinned knee)
- Growth – multicellular organisms grow by increasing the NUMBER of cells (not cell size) – elephants are bigger than dogs because of the number of cells not size of cells

Cell Transport

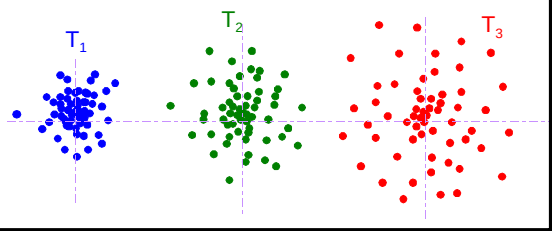
- Diffusion defined: The net movement of molecules from an area of high concentration to an area of low concentration.
- Example: Sugar or salt dissolving in water. Think Koolaide, instant coffee or tea, Crystal Lite

- Molecules are always in motion
- Difference between gas, liquid and solid



Diffusion

- Molecules in solution tend to slowly spread apart over time. This is *diffusion*.



Diffusion

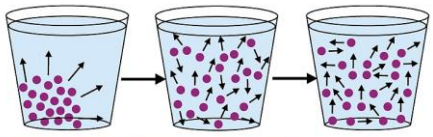


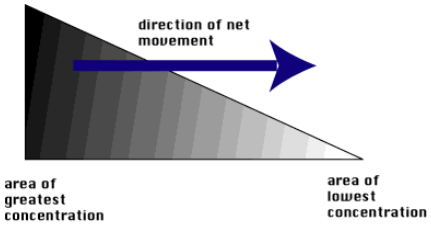
Figure 2.9 Molecular movement during diffusion. Although molecules move in every direction, the overall direction of movement is outward to areas of lower concentration. The colored circles in these figures represent molecules of dye.

concentrated, high energy molecules

[High] ⟶ [Low]

diffuse, low energy molecules

Concentration gradient

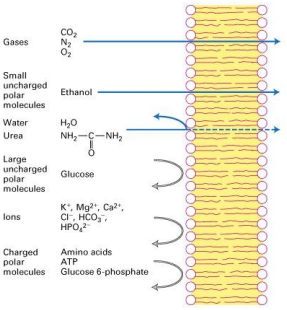


Diffusion in the Body

- Occurs across cell membranes
- The cell membrane is differentially permeable (selective)
- Movement of water across the membrane is called ***osmosis***

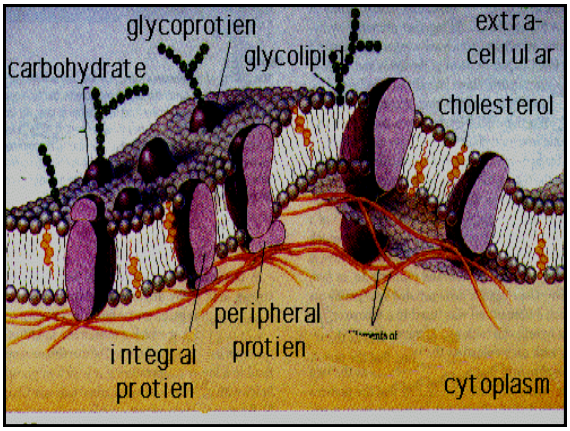
Movement of Molecules Across the Cell Membrane

- Oxygen and CO_2
- Water (Osmosis)
- Ions (Electrolytes)
- Sugar



Cell Membrane (Plasma Membrane)

- **<u>Selectively permeable</u>**
  - Small uncharged particles can cross such as gases (Oxygen and carbon dioxide gas) and water.
  - Charged particles (sodium ions, chloride ions, etc.) cannot cross or are slowed.
  - Large particles can't get through.



Chemicals that can pass through the membrane	Chemicals that cannot pass through the membrane
•Water •Carbon dioxide •Oxygen •Other very small nonpolar molecules such as ammonia and alcohols •Lipids such as cholesterol	•All ions including hydrogen ions! •mid to large polar and nonpolar molecules including glucose •Amino acids •Macromolecules such as proteins, polysaccharides

How materials get into and out of the cell

Passive transport mechanisms	Active Transport mechanisms
•Simple diffusion •Across membrane •Simple protein channels •Gated channels •Osmosis •Facilitated Diffusion	•Protein pumps •Vesicular transport •endocytosis •phagocytosis •pinocytosis •exocytosis

Cell Transport

- Definitions:
  - Solute – substance dissolved
  - Solvent – substance solute is dissolved in
  - Solution – combination of solvent and solute
- Passive vs. Active transport
  - Passive – occurs by molecular movement
  - Active – requires transport channels and the input of energy from ATP (adenosine triphosphate)

- Passive Transport: **Diffusion**
  - Solutes (or solvents) moving down their concentration gradient: high ⇨ low
  - Natural tendency, no energy required
  - Atoms/molecules always are in constant random movement, when they hit something ⇨ bounce back in the opposite direction

Cell Transport

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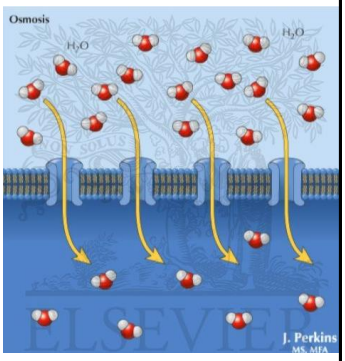
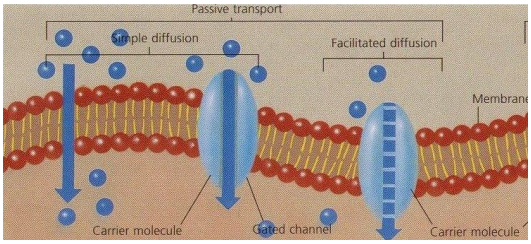
Osmosis

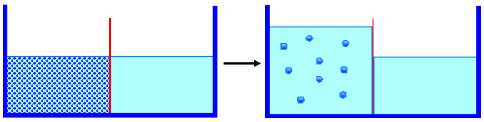


THE TWO TYPES OF PASSIVE TRANSPORT ARE: DIFFUSION (INCLUDING OSMOSIS) AND FACILITATED DIFFUSION.

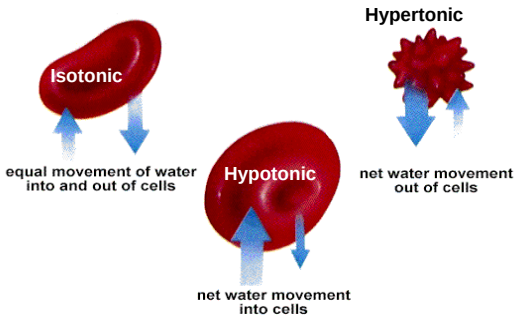


Osmosis

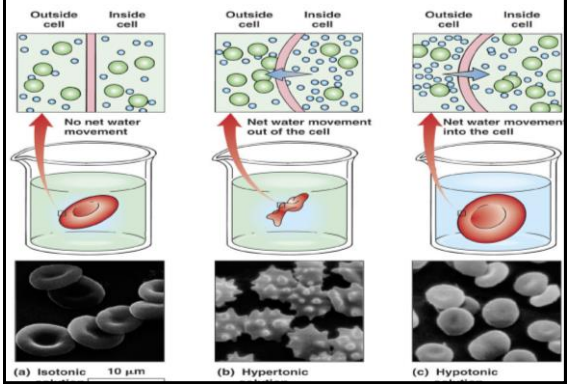
- Osmosis is the movement of *WATER* across a semi-permeable membrane
- At first the concentration of solute is very high on the left.
- But over time, the water moves across the semi-permeable membrane, and dilutes the particles.



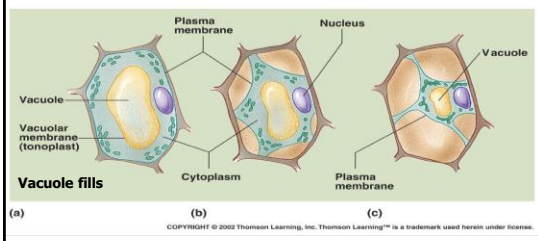
Biological Solution Concentrations



Animal Cells and Osmosis

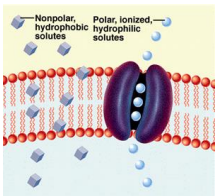


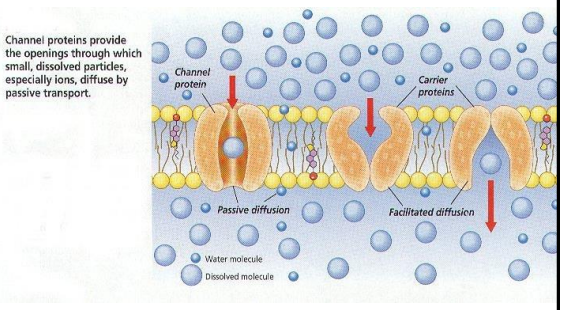
Plant Cells and Osmosis



Facilitated Diffusion

- Diffusion with the aid of a carrier protein.
- Eg.:



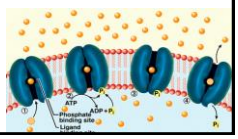


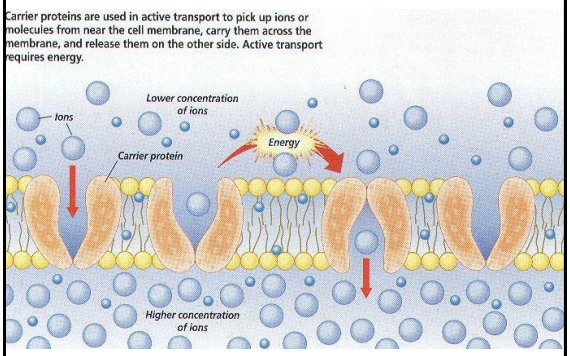
Membrane Transport: Active Processes

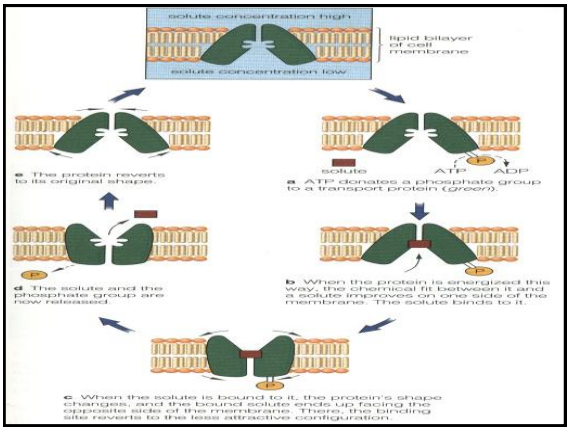
- Two types of active processes
  - **Protein Pumps**
  - **Vesicular transport**
- Both require ATP to move solutes across a plasma membrane because
  - Solute too large for channels
  - Solute not lipid soluble
  - Solute not able to move down concentration gradient

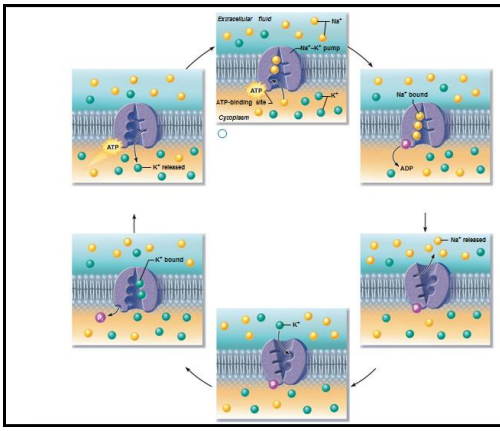
Protein Pumps

- Requires energy
- Pumps
  - To maintain a concentration gradient
  - From low conc. to high conc.
  - Against the natural tendency
  - Na/K pumps – pump Na out, K in
  - Ca pumps, H+ pumps, Cl- pumps









Vesicular Transport

- **Exocytosis**—transport out of cell
- **Endocytosis**—transport into cell
  - **Phagocytosis**
  - **Pinocytosis**
  - **Receptor-mediated endocytosis**
- **Transcytosis**—transport into, across, and then out of cell
- **Vesicular trafficking**—transport from one area to another

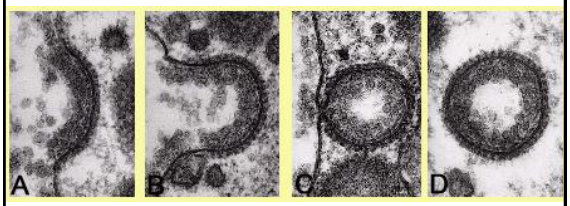
Endocytosis

- Endocytosis
  - {Endo (within) cytosis (cell) }
- Process in which a substance gains entry into a cell without passing through the cell membrane
- Subdivided into three different types:
  - –PINOCYTOSIS
  - –PHAGOCYTOSIS
  - –RECEPTOR MEDIATED ENDCYTOSIS

•In each case endocytosis results in the formation of an intracellular vesicle

- –Invagination of the plasma membrane and membrane fusion

•Different categories differ in exact mechanisms by which process occurs

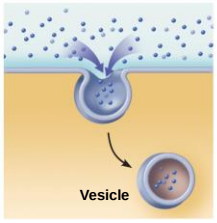


Microscope image of cell undergoing endocytosis. A. The cell membrane begins to sink
in. B. The membrane is attempting to envelop the material. C. The material has been
captured inside of a capsule of cell membrane. D. Endocytosis is complete.

Pinocytosis

- Plasma membrane forms an invagination
  - What ever substance is found within the area of invagination is brought into the cell
  - In general this material will be dissolved in water
    - Also referred to as "cellular drinking" to indicate that liquids and material dissolved in liquids are ingested by the cell.
- This is opposed to the ingestion of large particulate material like bacteria or other cells or cell debris

Figure 3.13b Comparison of three types of endocytosis.

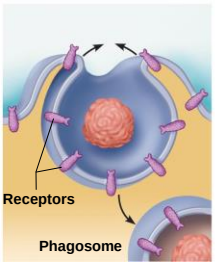


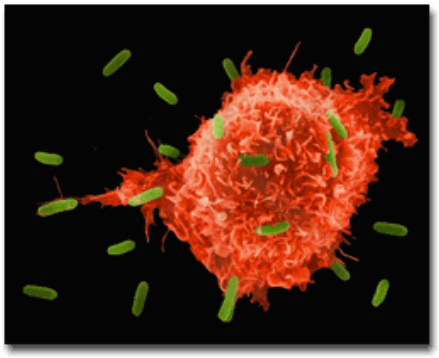
(b) Pinocytosis

Phagocytosis

- Form of endocytosis
  - Cell changes shape by sending out projections which are called pseudopodia (false feet)
- Phagocytic cells such as a macrophage may be attracted to a particle like a bacteria or virus by chemical attractant
  - This process is called chemotaxis (movement toward a source of chemical attractant)
- The phagocytic cell sends out membrane projections that make contact with some particle
  - Some sort of receptor ligand interaction occurs between the phagocytic cell surface and the particle that will be ingested
  - The pseudopodia then surround the particle and when the plasma membrane of the projection meet membrane fusion occurs
  - Results in formation of an intracellular vesicle

Figure 3.13a Comparison of three types of endocytosis.



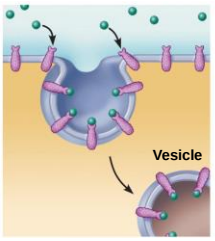


[Phagocytosis in action: A t-lymphocyte is attacking invading *E. coli* population.]

Receptor Mediated Endocytosis

Endocytotic mechanism
Specific molecules are ingested into the cell
Specificity results from a receptor-ligand interaction
- Receptors on the plasma membrane of the target tissue will specifically bind to ligands on the outside of the cell
- Endocytotic process occurs and the ligand is ingested

Figure 3.13c Comparison of three types of endocytosis.



Exocytosis

- Process in which an intracellular vesicle (membrane bounded sphere) moves to the plasma membrane and subsequent fusion of the vesicular membrane and plasma membrane ensues
- Many cellular processes involve exocytosis
  - For example a few of the processes that use exocytosis are:
    - Secretion of proteins like enzymes, peptide hormones and antibodies from cells
    - Turnover of plasma membrane